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**Murakami**

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(54) **HYDRAULIC SHOCK ABSORBER**

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***F16F 9/06*** (2006.01)

(52) **U.S. Cl.** ..... **188/314**; 188/297; 188/318; 267/64.26; 267/225

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See application file for complete search history.

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(57) **ABSTRACT**

In a front fork in which a partition wall member is provided in an inner periphery of an inner tube, a working fluid chamber is comparted under the partition wall member and an oil reservoir chamber is comparted over the partition wall member, a main suspension spring is interposed between an upper spring bearing in a piston rod side attached to an outer tube side and a lower spring bearing in a bottom portion side of the inner tube, within the working fluid chamber of the inner tube, and a sub suspension spring is interposed between an upper spring bearing in an upper end portion side of the outer tube side and a lower spring bearing in the partition wall member provided in an inner periphery of the inner tube, within the oil reservoir chamber of the inner tube.

**4 Claims, 4 Drawing Sheets**

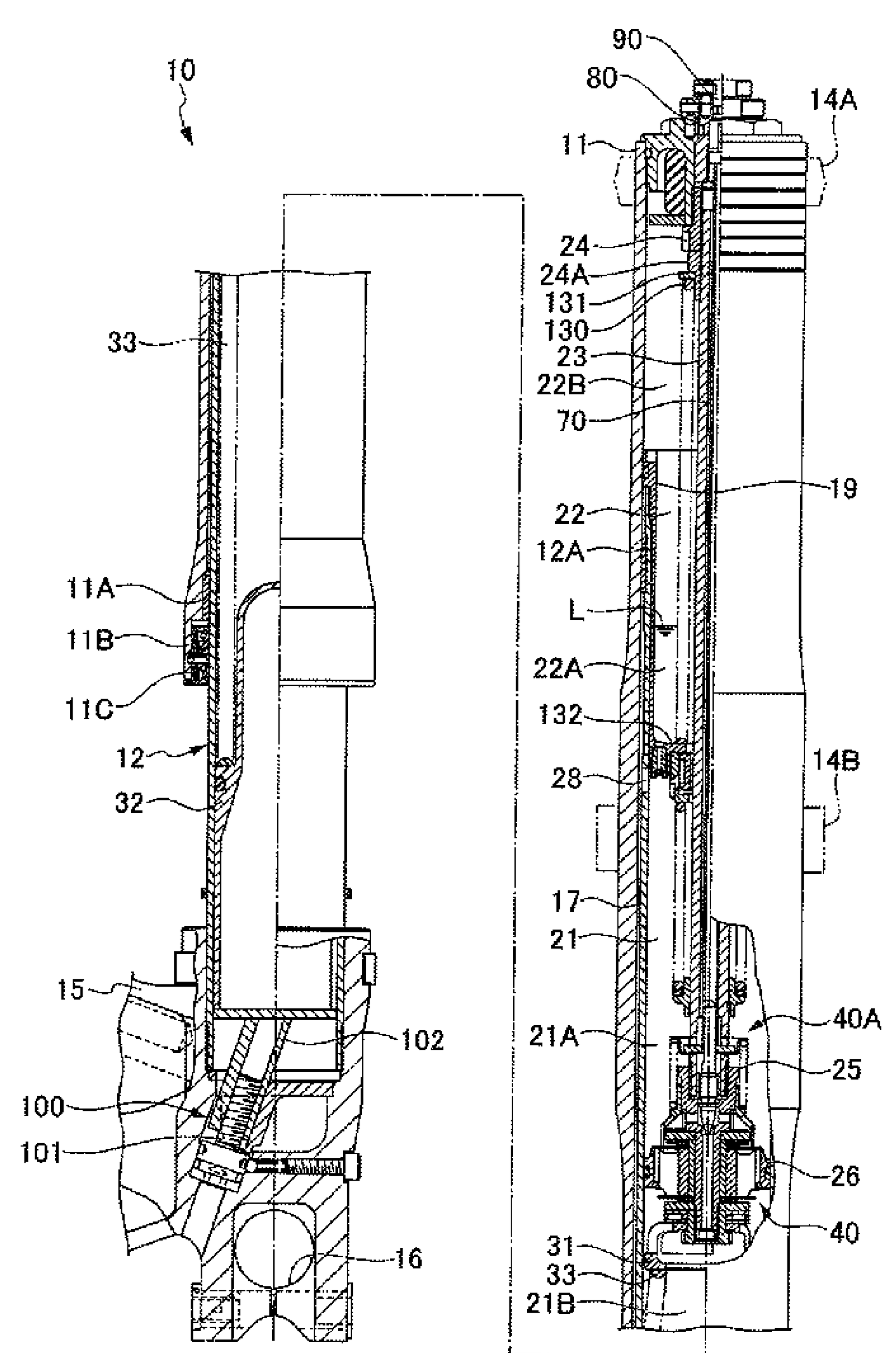
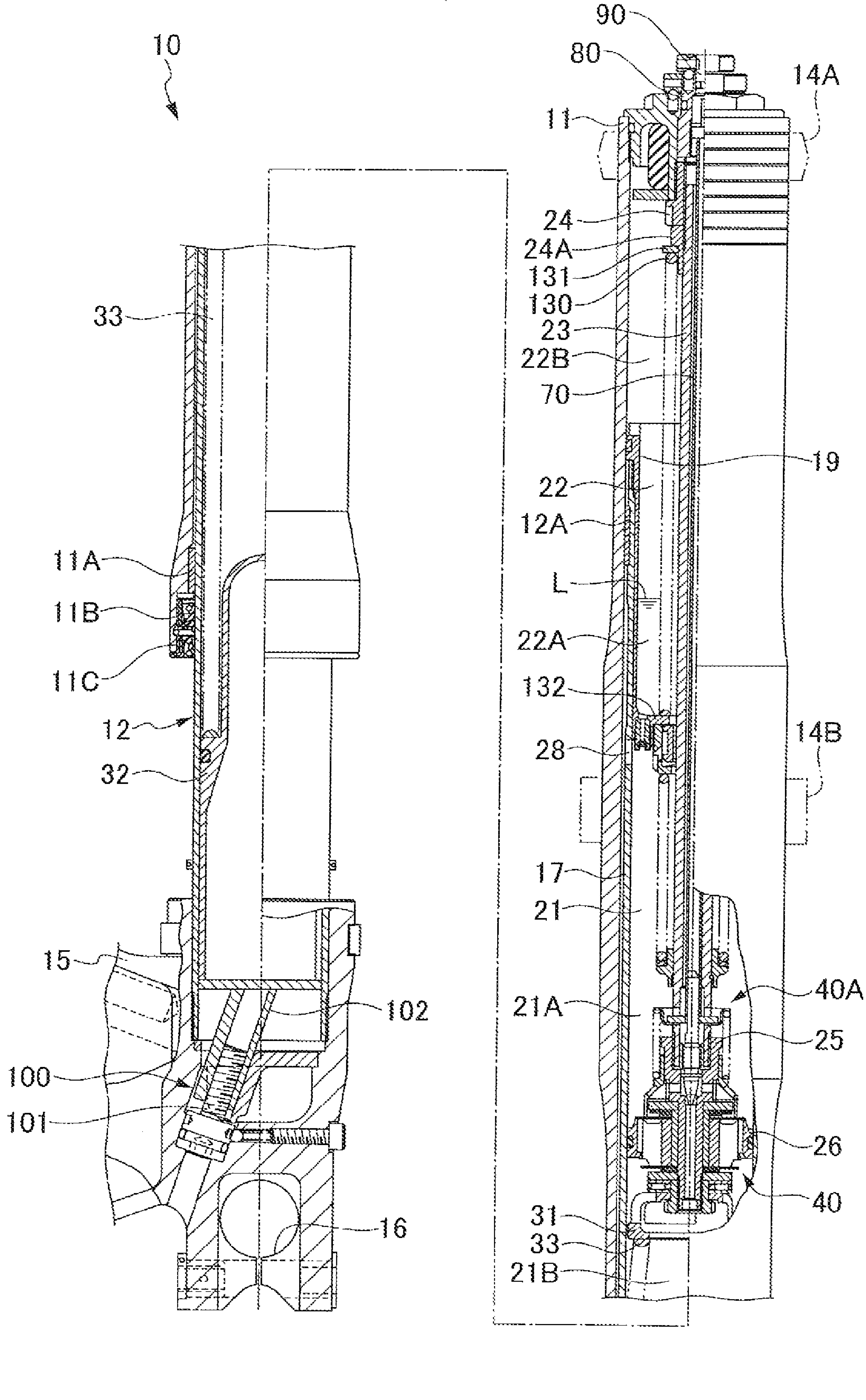


FIG.1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21B

FIG.2

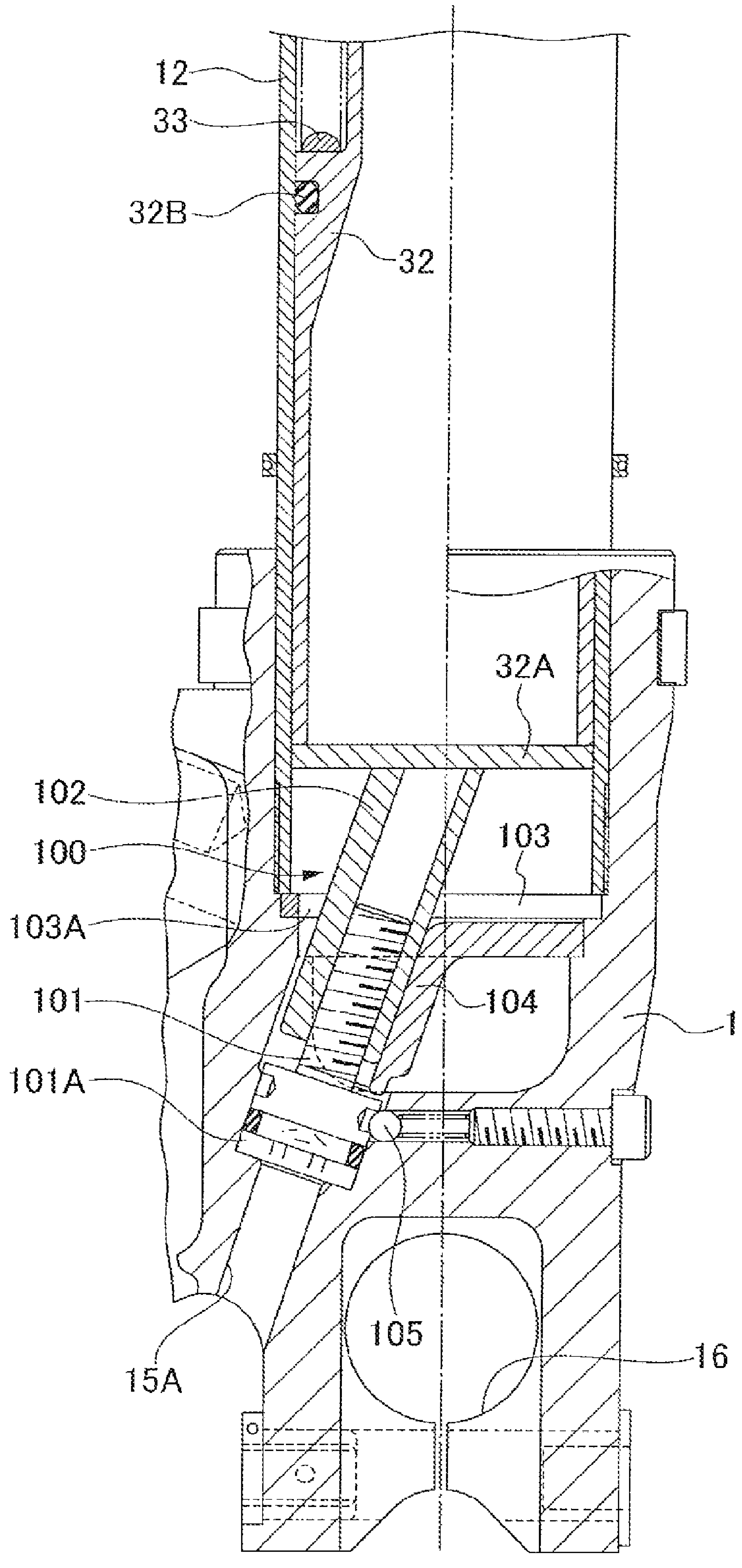
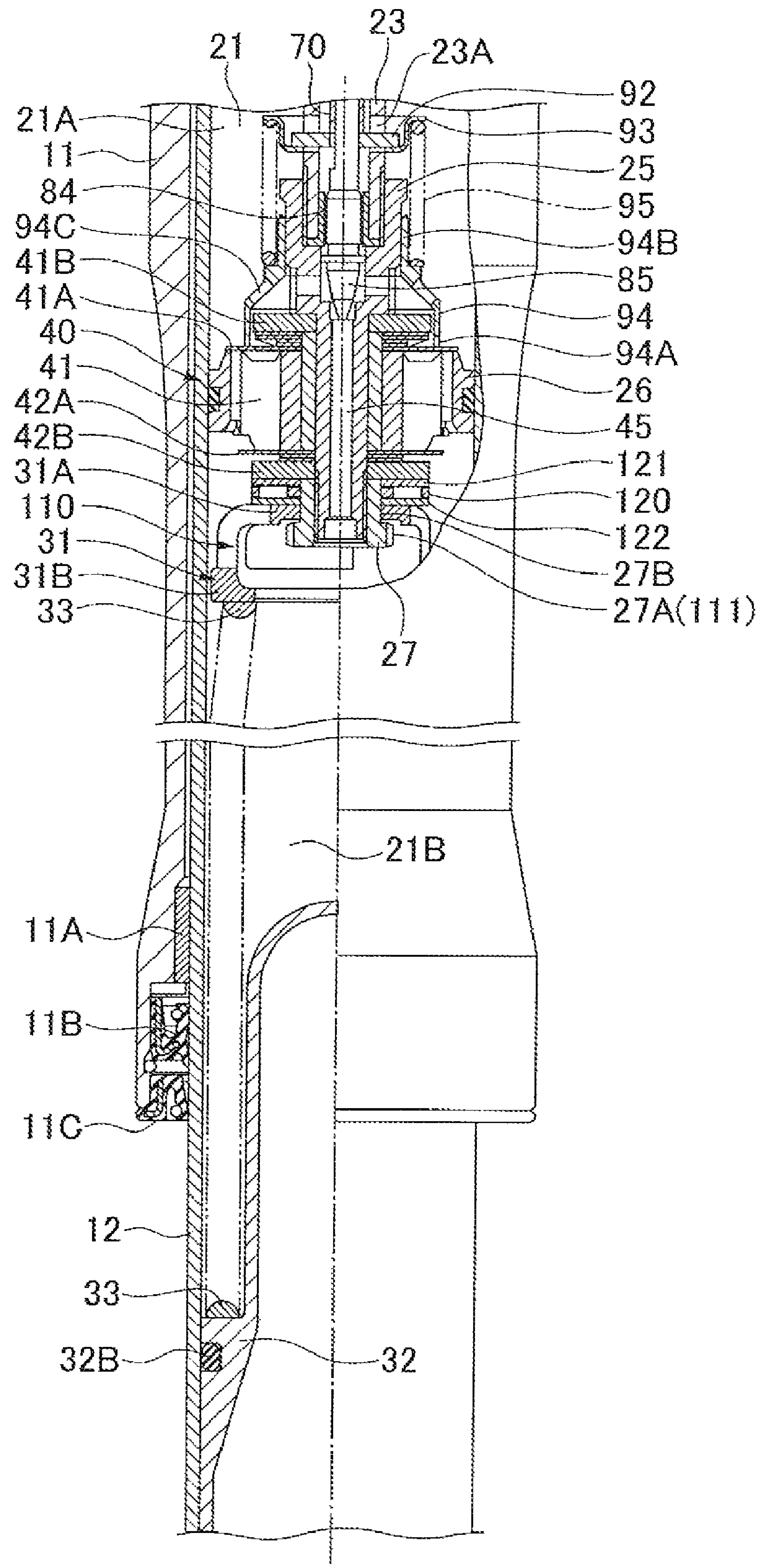


FIG.3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110
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32B
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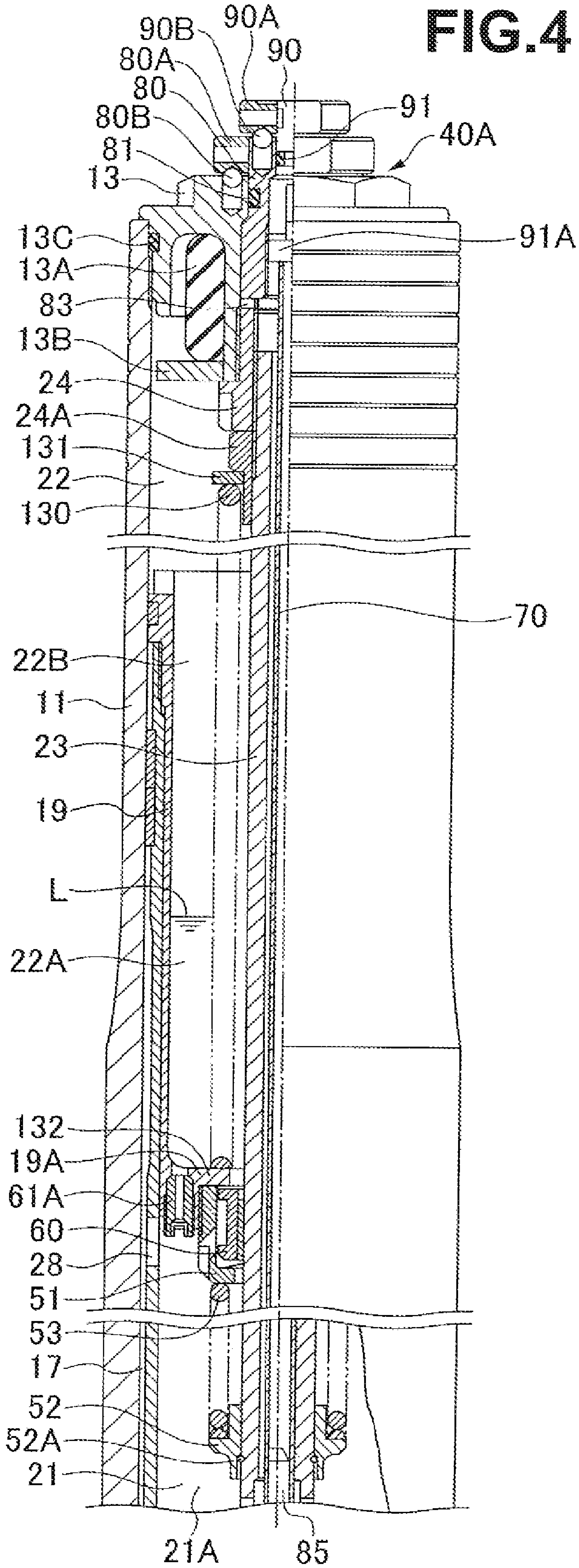
FIG.4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22A
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61A
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52A
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21A
85

# HYDRAULIC SHOCK ABSORBER

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a hydraulic shock absorber for a vehicle. The hydraulic shock absorber according to the invention having significant, tuning and maintenance efficiencies.

2. Description of the Related Art

As a hydraulic shock absorber, as described in Japanese Patent Application Laid-Open (JP-A) No. 56-82680 (patent document 1), there is a structure in which an inner tube in an axle side is slidably inserted into an outer tube in a vehicle body side, a partition wall member is provided in an inner periphery of the inner tube, a working fluid chamber is comparted under the partition wall member, an oil reservoir chamber is comparted over the partition wall member, a piston supporting member attached to the outer tube side is inserted into the working fluid chamber through the partition wall member, and a piston sliding within the working fluid chamber is provided in a leading end portion of the piston supporting member. In this hydraulic shock absorber, a main suspension spring is interposed between an upper spring bearing in the piston supporting member side attached to the outer tube side and a lower spring hearing in a bottom portion, side of the inner tube, within the working fluid chamber of the inner tube.

The following disadvantages exist in the hydraulic shock absorber described in the patent document 1.

(1) To change a spring constant of the suspension spring, it is necessary to detach a partition wall member provided in an upper end portion of the inner tube and draw off the piston supporting member from the working fluid chamber in the inner tube in addition to detaching a cap from an upper end portion of the outer tube, in order to replace the suspension spring. Accordingly, many man hours are required.

(2) If the suspension spring is soaked into the working fluid chamber of the inner tube during replacement of the suspension spring; an oil amount is largely reduced in the working fluid chamber, because a coil diameter and a wire diameter of the suspension spring are thick and a surface area thereof is large. Accordingly, it is necessary to adjust the oil amount each time when the spring is replaced.

(3) If the suspension spring inserted to the working fluid chamber of the inner tube is replaced, an oil flow path flowing through a space between coils of the suspension spring is changed in an inner portion of the working fluid chamber, and a change of a damping force characteristic is generated.

## SUMMARY OF THE INVENTION

An object of the present invention is to simplify spring replacement so as to suppress a change of a damping force characteristic on the basis of the spring replacement, in a hydraulic shock absorber.

The present invention relates to a hydraulic shock absorber in which an inner tube in an axle side is slidably inserted into an outer tube in a vehicle body side, a partition wall member is provided in an inner periphery of the inner tube, a working fluid chamber is comparted under the partition wall member, an oil reservoir chamber is comparted over the partition wall member, a piston support member attached to the outer tube side is inserted into the working fluid chamber through the partition wall member, and a piston sliding within the working fluid chamber is provided in a leading end portion of the piston support member. A main suspension spring is interposed between an upper spring bearing in the piston support



member side attached to the outer tube side and a lower spring bearing in a bottom portion side of the inner tube, within the working fluid chamber of the inner tube. A sub suspension spring is interposed between an upper spring bearing on an upper end portion side of the outer tube side and a lower spring bearing on the partition wall member side provided in an inner periphery of the inner tube, within the oil reservoir chamber of the inner tube.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood from the detailed description given below and from the accompanying drawings which should not be taken to be a limitation on the invention, but are for explanation and understanding only.

The drawings:

FIG. **1** is a cross sectional view showing a hydraulic shock absorber;

FIG. **2** is a cross sectional view of a lower portion in FIG. **1**;

FIG. **3** is a cross sectional view of an internal portion in FIG. **1**; and

FIG. **4** is a cross sectional view of an upper portion in FIG. **1**.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

A front fork, which may be a hydraulic shock absorber, **10** is constituted by an inverted type front fork in which an outer tube **11** is arranged in a vehicle body side, and an inner tube **12** is arranged in a wheel side, and is structured, as shown in FIGS. **1** to **4**. The inner tube **12** is slidably inserted to an inner portion of the outer tube **11** via a guide bush **11**A fixed to an inner periphery of a lower end opening portion of the outer tube **11**. A guide bush **12**A is fixed to an outer periphery of an upper end opening portion of the inner tube **12**. Reference numeral **11**B denotes an oil seal, and reference numeral **11**C denotes a dust seal. A cap **13** is screwed to the upper end opening portion of the outer tube **11** in a liquid tight manner. Vehicle body side mounting members **14**A and **14**B are provided in an outer periphery of the outer tube **11**. An axle bracket **15** is inserted and attached to the lower end opening portion of the inner tube **12** in a liquid tight manner so as to construct a bottom portion of the inner tube **12**, and an axle mounting hole **16** is provided in the axle bracket **15**.

The front fork **10** is provided with an annular oil chamber **17** comparted by an inner periphery of the outer tube **11**, an outer periphery of the inner tube **12**, and two guide bushes **11**A and **12**A mentioned above.

The front fork **10** is provided with a closed-end cup-shaped partition wall member **19** in a liquid tight manner in an upper end side inner periphery of the inner tube **12** via an O-ring or the like, that comparts a working fluid chamber **21** under a rod guide portion **19**A in a bottom portion of the partition wall member **19**, and comparts an oil reservoir chamber **22** over an upper portion of the rod guide portion **19**A. A lower region in the oil reservoir chamber **22** corresponds to an oil chamber **22**A, and an tipper region corresponds to an air chamber **22**B. A guide bush **12**A provided in an outer periphery of an upper end portion protruding from the inner tube **12** of the partition wall member **19** comes into slidable contact with an inner periphery of the outer tube **11**.

The front fork **10** is structured such that a piston rod **23** attached to the outer tube **11** is slidably inserted to the rod guide portion **19**A of the partition wall member **19**. Specifically, a hollow piston rod **23** is screwed to a mounting collar **24** screwed to a lower end portion of a center portion of the cap **13**, and is fixed by a lock nut **24**A.

The front fork **10** is structured such that a piston **26** brought into slidable contact with an inner periphery of the inner tube **12** is fixed to a piston bolt **25** screwed to a leading end portion of the piston rod **23** inserted to the inner tube **12** from the rod guide portion **19**A of the partition wall member **19**, and the oil chamber **21** is comparted into a piston rod side oil chamber **21**A in which the piston rod **23** is accommodated, and a piston side oil chamber **21**B in winch the piston rod **23** is not accommodated. The piston **26** is fixed by a piston nut **27**.

The front fork **10** always communicates the annular oil chamber **17** with the piston rod side oil chamber **21**A via an oil hole **28** provided in the inner tube **12**.

The front fork **10** is structured such that an upper spring bearing **31** is attached to a side of a lower end surface facing to the piston side oil chamber **21**B of the piston **26** as mentioned below, a lower spring bearing **32** is arranged in a bottom portion of the inner tube **12** formed by the axle bracket **15**, and a main suspension spring **33** is interposed between the upper spring bearing **31** and the lower spring bearing **32**. The entire main suspension spring **33** is wetted by oil within the piston side oil chamber **21**B. The front fork **10** absorbs an impact force applied from a road surface when a vehicle travels on the basis of an extending and contracting oscillation of the main suspension spring **33** and sub suspension spring **130** mentioned below. At this time, a spring load adjusting apparatus **100** mentioned below moves the lower spring bearing **32** upward and downward so as to freely adjust a spring load of the suspension spring **33**.

The front fork **10** is provided with a damping force generating apparatus **40** in the piston **26** (FIGS. **3** and **4**).

The damping force generating apparatus **40** is provided with a compression side flow path **41** and an extension side flow path (not shown). The compression side flow path **41** is opened and closed by a compression side disc valve **41**A (a compression side damping valve) backed up to a valve stopper **41**B. The extension side flow path is opened and closed by an extension side disc valve **42**A (an extension side damping valve) backed up to a valve stopper **42**B. In this case, the valve stopper **41**B, the valve **41**A, the piston **26**, the valve **42**A and the valve stopper **42**B construct a valve assembly attached to a piston bolt **25**, and is pinched by a piston nut **27** screwed to the piston bolt **25**.

The damping force generating apparatus **40** is structured such that a damping force adjusting apparatus **40**A mentioned in detail below is provided in a center portion of the cap **13**, a needle valve **85** of the damping force adjusting apparatus **40**A is inserted to a hollow portion of the piston rod **23**, and an opening degree of a bypass path **45** provided in the piston rod **23** is adjusted by an upward and downward movement of the needle valve **85**. The bypass path **45** bypasses the piston **26**, and communicates the piston rod side oil chamber **21**A with the piston side oil chamber **21**B.

The damping force generating apparatus **40** generates a compression side damping force in a low speed range in a compression side stroke on the basis of a passage resistance of the bypass path **45** an opening degree of which is regulated by the needle valve **85**, and generates a compression side damping force in high and middle speed ranges on the basis of a deflection deformation of the compression side disc valve **41**A. Further, it generates an extension side damping force in a low speed range in an extension side stroke on the basis of a passage resistance of the bypass path **45** an opening degree of which is regulated by the needle valve **85**, and generates an extension side damping force in middle and high speed ranges on the basis of a deflection deformation of the extension side disc valve **42**A. The extending and contracting oscillation of the suspension spring **33** mentioned above is controlled by the compression side damping force and the extension side damping force.

The front fork **10** is structured such that a stopper rubber **13**A and a stopper plate **13**B with which an upper end portion of the partition wall member **19** provided in the inner tube **12** collides at a maximum compression stroke are firmly fixed to a lower end surface of the cap **13**, and the maximum compression stroke is controlled by the stopper rubber **13**A.

The front fork **10** is structured such that a rebound spring **53** is interposed between a spring sheet **51** threadedly engaged to a lower end surface facing to the piston rod side oil chamber **21**A of the partition wall member **19** in an upper end side of the inner tube **12**, and a spring sheet **52** locked to a stopper ring **52**A provided in the piston rod **23**. The partition wall member **19** pressurizes the rebound spring **53** with respect to the spring sheet **52** at a time of a maximum extension of the front fork **10**, thereby controlling the maximum extension stroke.

In this case, in the front fork **10**, a cross sectional area S1 of the annular oil chamber **17** formed by an annular gap between the outer tube **11** and the inner tube **12** is formed larger than a cross sectional area (an area surrounded by an outer diameter) S2 of the piston rod **23** (S1>S2).

Further, the rod guide portion **19**A of the partition wall member **19** and the spring sheet **51** are provided with a check valve **60** which allows an oil flow from the oil reservoir chamber **22** to the piston rod side oil chamber **21**A in the compression side stroke and blocks the oil flow from the piston rod side oil chamber **21**A to the oil reservoir chamber **22** in the extension side stroke.

Further, since the rod guide portion **19**A of the partition wall member **19** is structured such that an oil seal is not sealed and attached to a periphery of the piston rod **23**, a small flow path (an orifice) **61** (not shown) communicating the piston rod side oil chamber **21**A with the oil reservoir chamber **22** is structured by a small gap which the bush pressure inserted to the inner periphery of the check valve **60** forms around the piston rod **23**. The small flow gap **61** may be pierced in the rod guide portion **19**A of the partition wall member **19**, and may be constituted by an orifice means **64**A communicating the piston rod side oil chamber **21**A with the oil reservoir chamber **22**.

An operation of the front fork **10** is as follows.

(Compression Side Stroke)

In the compression side stroke, a working fluid at an approaching volumetric capacity of the piston rod **23** going into the inner tube **12** in the compression side stroke is transferred to the annular oil chamber **17** from the oil chamber **21**A in the inner periphery of the inner tube **12** via an oil hole **28** of the inner tube **12**. At this time, since a volumetric capacity increase amount ΔS1 (a supply amount) of the annular oil chamber **17** is larger than a volumetric capacity increase amount ΔS2 of the piston rod **23**, a shortfall (ΔS1−ΔS2) in an oil necessary supply amount to the annular oil chamber **17** is supplied from the oil reservoir chamber **22** via the check valve **60**.

In this compression side stroke, as mentioned above, the compression side damping force is generated in the low speed range on the basis of the passage resistance of the bypass path **45** the opening degree of which is adjusted by the needle valve **85**, and generates the compression side damping force in the middle and high speed ranges on the basis of the deflection deformation of the compression side disc valve **41**A.

(Extension Side Stroke)

In the extension side stroke, the working fluid at a retraction volumetric capacity amount of the piston rod **23** going out of the inner tube **12** in the extension side stroke is transferred to the oil chamber **21**A in the inner periphery of the inner tube **12** from the annular oil chamber **17** via the oil hole **28** of the inner tube **12**. At this time, since the volumetric capacity reduction amount. ΔS**1** (a discharge amount) of the annular oil chamber **17** is larger than the volumetric capacity reduction amount ΔS**2** of the piston rod **23**, a surplus amount (ΔS**1**−ΔS**2**) in the discharge amount of the oil from the annular oil chamber **17** is discharged to the oil reservoir chamber **22** via the small flow path **61**.

In this extension side stroke, as mentioned above, the extension side damping force is generated in the low speed range on the basis of the passage resistance of the bypass path **45** the opening degree of which is adjusted by the needle valve **85**, and the extension side damping force is generated in the middle and high speed ranges on the basis of the deflection deformation of the extension side disc valve **42**A. Further, the extension side damping force is also generated on the basis of the passage resistance of the small flow path **61** mentioned above.

A description will be given below of the damping force adjusting apparatus **40**A.

The damping force adjusting apparatus **40**A is structured, as shown in FIGS. **3** and **4**, such that a hollow portion of the piston rod **23** is provided with only one push rod **70** having a non-circular cross section which is movable in a rotational direction and an axial direction, a D-shaped cross section in the present embodiment. A first adjusting portion **80** and a second adjusting portion **90** are coaxially arranged in an upper portion of the front fork **10** and on an extension of the bush rod **70**. In this case, the first adjusting portion **80** moves the push rod **70** in the rotational direction, and the second adjusting portion **90** moves the push rod **70** in the axial direction. Further, the damping force adjusting apparatus **40**A is structured such that the needle valve **85** slidably locking into the non-circular cross section of the push rod **70** is screwed with the hollow portion of the piston rod **23**, the needle valve **85** is moved via a screwing motion on the basis of a rotation of the first adjusting portion **80**. An opening degree of the bypass path **45** is adjusted by the needle valve **85**, and the damping force on the basis of the passage resistance of the bypass path **45** can be adjusted by extension. Further, the damping force adjusting apparatus **40**A energizes a compression side disc valve **41**A in a closing direction of the compression side disc valve **41**A, by a spring **95** which collides with the push rod **70** in the axial direction, and can adjust the compression side damping force on the basis of the deflection deformation of the compression side disc valve **41**A. A description will be given below of structures of the first adjusting portion **80** and the second adjusting portion **90**, a damping force adjusting structure using the needle valve **85**, and a damping force adjusting structure using the spring **95**.

(Structure of First Adjusting Portion **80** and Second Adjusting Portion **90**) (FIGS. **3** and **4**)

The cap **13** constituting a cap assembly is screwed to an upper end opening portion of the outer tube **11** in a liquid tight manner via an O-ring **13**C. A mounting collar **24** is screwed to a lower end opening side of the cap **13**, and an upper end portion of the piston rod **23** is screwed to the mounting collar **24** so as to be fixed by the lock nut **24**A.

The first adjusting portion **80** is inserted and attached in a liquid tight manner from a lower end opening side of a center hole of the cap **13** via an O-ring **81**. The first adjusting portion **80** is engaged with an intermediate step portion of the cap **13** in an axial direction so as to be prevented from coming off to an upper side, and comes into contact with an upper end surface of the mounting collar **24** screwed to the lower end opening side of the cap **13** in the axial direction to prevent it from coming off to a lower side. As a result, the first adjusting portion **80** is rotatably provided in the cap **13** by using an operation knob **80**A in an outer periphery of an upper end. A lower end surface coming into contact with the mounting cover **24** of the first adjusting portion **80** is provided with a horizontal groove, and both side projections of an engagement piece **83** are engaged with the horizontal groove with approximately no play in the rotational direction. An outer periphery of the non-circular cross section (the D-shaped cross section) of the push rod **70** is passed through a non-circular hole (a D-shaped hole) provided in the center of the locking piece **83**, is engaged in the rotational direction with approximately no play, and is slidable in the axial direction. Accordingly, the first adjusting portion **80** can move the push rod **70** in the rotational direction. Reference numeral **80**B denotes a detent mechanism with respect to the operation knob **80**A.

The second adjusting portion **90** is inserted and attached in a liquid tight manner from a lower end opening side of a center hole of the first adjusting portion **80** via an O-ring **91**, and is engaged with an intermediate step portion of the first adjusting portion **80** in an axial direction so as to be prevented from coming off to an upper side. A pressing element **91**A is engaged with a lower end portion of the second adjusting portion **90** in such a manner as to be engaged in the rotational direction and be slidable in the axial direction. A lower end surface of the pressing element **91**A comes into contact with an upper end surface of the push rod **70** passing through the non-circular hole of the engagement piece **83** engaging with the side of the first adjusting portion **80** with no gap in the axial direction. In this case, the push rod **70** is energized upward by a spring force of a spring **95** mentioned later, and an upper end surface thereof always comes into contact with the lower end surface of the pressing element **91**A of the second adjusting portion **90**. The second adjusting portion **90** is moved by a screwing motion with respect to the first adjusting portion **80** by using the operation knob **90** in the upper end surface, and can move the push rod **70** in the axial direction. Reference numeral **90**B denotes a detent mechanism with respect to the operation knob **90**A.

(Damping Force Adjusting Structure Using Needle Valve **85**) (FIG. **3**)

An inner base **84** is inserted and attached to a lower end portion of the hollow portion of the piston rod **23**, and a lower end surface of the piston rod **23** and an inner diameter step portion of the piston bolt **25** fixes a lower end flange of the inner base **84** in a pinching manner. The inner base **84** may be press-fit into the hollow portion of the piston rod **23**. The needle valve **85** is inserted in a liquid tight manner to an inner periphery of the inner base **84** fixed to the piston rod **23** as mentioned above, and a thread portion of an intermediate portion of the needle valve **85** is screwed to the inner periphery of the piston bolt **25**. The non-circular cross section of the upper end portion of the needle valve **85**, the non-circular cross sectional portion formed in the D-shaped cross section in the present embodiment, is locked into the non-circular cross section in the lower end portion of the push rod **70** inserted to the hollow portion of the piston rod **23** with approximately no play, in such a manner as to be slidable in the axial direction and be engaged in the rotational direction.

If the first adjusting portion **80** moves the push rod **70** in the rotational direction as mentioned above, the needle valve **85** engaging with the push rod **70** in the rotational direction is moved by a screwing motion with respect to the piston bolt **25**, and is moved forward and backward with respect to the valve sheet in the upper end portion of the vertical hole of the bypass path **45** provided in the piston bolt **25**. The needle valve **85** adjusts the opening degree of the bypass path **45**, and can adjust the damping force in the compression side and the extension side on the basis of the passage resistance of the bypass path **45** by extension.

In this case, when the first adjusting portion **80** moves, by a screwing motion, the needle valve **85** via the push rod **70**, the needle valve **85** idle moves with respect to the center hole of the pressing piece **92** for the spring **95** mentioned later, and does not affect the spring **95**.

(Damping Force Adjusting Structure Using Spring **95**) (FIG. **3**)

Long hole-shaped guide holes **23**A extending in an axial direction are provided in both sides in a diametrical direction of the lower end side of the piston rod **23**, and both side projections of the pressing piece **92** are locked into the guide holes **23**A approximately with no play so as to be slidable in the axial direction. The lower end surface of the push rod **70** inserted to the hollow portion of the piston rod **23** comes into direct contact with the upper surface of the pressing piece **92**. The non-circular cross sectional portion of the needle valve **85** locked into the lower end portion of the push rod **70** as mentioned above is loosely fitted to a circular hole provided in the center of the pressing piece **92** in such a manner as to be movable in the axial direction.

Around the lower end portion (the piston bolt **25**) of the piston rod **23**, there are arranged a spring bearing **93** which contacts both end projections of the pressing piece **92** from the lower side, and a valve presser foot **94** which collides with an upper surface (a back surface) of the compression side disc valve **41**A, and the valve pressing spring **95** is interposed between the spring bearing **93** and the valve presser foot **94**. The spring bearing **93** is formed in a cup shape, comes into contact with both side projections of the pressing piece **92** in the lower end of the inner periphery of the cup, and seats the spring **95** on the upper end outer peripheral flange of the cup. The valve presser foot **94** is provided with a circular ring-shaped pressing portion **94**A which comes into contact with an appropriate outer diameter position on the upper surface of the compression side disc valve **41**A circumferentially continuously (or intermittently). A slide portion **94**B is slidably guided to the upper end outer periphery of the piston bolt **25**, and an oil path **94**C communicates the piston rod side oil chamber **21**A with the compression side flow path **41**, the extension side flow path, and the bypass path **45**, and seats the spring **95** on an outer peripheral step portion.

If the second adjusting portion **90** moves the push rod **70** in the axial direction as mentioned above, the pressing piece **92** with which the lower end surface of the push rod **70** contacts moves the spring bearing **93** upward and downward so as to extend and compress the valve pressing spring **95**, and adjusts a set load of the spring **95**. Accordingly, the set load of the spring **95** energizes the compression side disc valve **41**A in a direction of closing the compression side disc valve **41**A via the valve presser foot **94**, and it is possible to adjust the compression side damping force on the basis of the deflection deformation of the compression side disc valve **41**A. The valve presser foot **94** can be replaced by a structure in which the diameter of the presser foot portion **94**A is different. The valve presser foot **94** provided with the large-diameter presser foot portion **94**A presses the outer peripheral side of the compression side disc valve **41**A so as to enlarge the damping force from the low speed range of the piston speed. The valve presser foot **94** provided with the small-diameter presser foot portion **94**A presses the inner peripheral side of the compression side disc valve **41**A so as to enlarge the damping force in the middle to high speed range of the piston speed.

In this case, when the second adjusting portion **90** moves the pressing piece **92** via the push rod **70**, the push rod **70** and the pressing piece **92** idle move in the axial direction with respect to the needle valve **85**, and does not affect the needle valve **85**.

Next, a description will be given of a spring load adjusting apparatus **100** adjusting the spring load of the suspension spring **33** by moving the lower spring bearing **32** upward and downward. In this case, the lower spring bearing **32** is formed in a closed-end tubular shape, has a bottom plate **32**A contacting against, a lower end portion, and is inserted to an inner periphery of the inner tube **12** so as to be movable upward and downward via an O-ring **32**B.

The spring load adjusting apparatus **100** supports the bottom plate **32**A of the lower spring bearing **32** by an adjustment bolt **101** facing an external portion at a position deviated from, the axle mounting hole **16** of the axle bracket **15** constituting the bottom portion of the inner tube **12** (near a side of the axle mounting hole **16**), as shown in FIG. **2**, and moves the lower spring bearing **32** upward and downward in accordance with a screw motion of the adjustment bolt **101** so as to adjust the spring load of the suspension spring **33**.

At this time, the adjustment bolt **101** is arranged obliquely with respect to a center axis passing through the axle mounting hole **16** of the inner tube **12**, and supports the adjust bolt **101** in the inner surface of the bottom portion of the inner tube **12** in a state of preventing the adjust bolt **101** from coming off to the external portion. An operation portion **101**A of the adjust bolt **101** is faced to the external portion from an operating hole **15**A of the axle bracket **15**. Further, an adjustment nut **102** is screwed with a threaded portion of the adjustment bolt **101** facing the inner portion of the inner tube **12**. The adjustment nut **102** is prevented from rotating by a rotation preventing means provided in the inner portion of the inner tube **12**, and makes the bottom plate **32**A of the lower spring bearing **32** come into contact with a leading end of the adjust nut **102**. The rotation preventing means **103** is constituted by a washer pinched between the inner tube **12** and the axle bracket **15**, and inserts a deformed portion of the adjust nut **102** to a rotation preventing deformed slit **103**A provided in the washer. Further, a slider **104** is provided in a lower portion of the rotation preventing means **103** in the bottom portion of the inner tube **12**. An outer surface of the adjustment nut **102** is slidably guided by the slider **104**, and the adjustment bolt **101** can not be pressed from the external portion. Reference numeral **105** denotes a detent mechanism with respect to the adjustment bolt **101**.

If the adjustment bolt **101** is moved by a screwing motion via the operation portion **101**A by a tool inserted to the operating hole **15**A of the axle bracket **15**, the adjust nut **102** is moved upward and downward, and the lower spring bearing **32** (the bottom plate **32**A) coming into contact with the adjust nut **102** is moved upward and downward. The lower spring bearing **32** adjusts an initial length of the suspension spring **33** with respect to the upper spring bearing **31** in the piston rod **23** side, and adjusts the spring load of the suspension spring **33**.

A description will be given below of an upper spring bearing attaching structure **110** which can reduce the rotational friction which the upper and lower spring bearings **31** and **32** apply to the suspension spring **33** when the suspension spring **33** is extended and compressed.

The upper spring bearing attaching structure **110** attaches the upper spring bearing **31** to the leading end portion of the piston bolt **25** of the piston rod **23** corresponding to the piston support member, that is, the leading end portion of the piston bolt **25** closer to the suspension spring **33** than the piston **26**, in such a manner as to be rotatable and also prevented from falling away, as shown in FIG. **3**.

Specifically, at a time of setting the piston nut **27** fixing the piston **26**, the disc valves **41**A and **42**A, and the valve stoppers **41**B and **42**B in the leading end portion of the piston bolt **25**, as mentioned above, the structure is made such that the piston nut **27** has a tool engagement portion **27**A and a small-diameter portion **27**B having a smaller diameter than the tool engagement portion **27**A formed in a step shape near the tool engagement portion **27**A. An end surface of the small-diameter portion **27**B of the piston nut **27** screwed to the piston bolt **25** is brought into contact with the valve stopper **42**B. Further, the tool engagement portion **27**A of the piston nut **27** is formed as an outer evagination portion **111**, and the upper spring bearing **31**, a bearing member **120** and upper and lower bearing races **121** and **122** are loaded to the small-diameter portion **27**B.

The upper spring bearing **31** is formed as a perforated cage shape, is provided with an attaching seat **31**A which is inserted into the small-diameter portion **27**B of the piston nut **27**, can be engaged with the tool engagement portion **27**A (the outer peripheral evagination portion **111**) and collides with the lower bearing race **122**, in a center portion of a cage bottom portion, and is provided with an annular spring bearing seat **31**B in a cage opening portion. Reference symbol **31**C denotes a flow path.

The bearing member **120** holds a roller in each of a plurality of holding grooves which are provided side by side in a peripheral direction of a perforated disc-shaped holder attached to the small-diameter portion **27**B of the piston nut **27**. The bearing races **121** and **122** are formed in a perforated disc shape attached to the small-diameter portion **27**B of the piston nut **27**.

Accordingly, the upper spring bearing attaching structure **110** is assembled by screwing the piston nut **27** on which is already installed the bearing member **120** and the bearing races **121** and **122** to the small-diameter portion **27**B to the piston bolt **25**, when constructing the valve assembly mentioned above by inserting and attaching the piston **26**, the disc valves **41**A and **42**A and the valve stoppers **41**B and **42**B to the piston bolt **25**. Accordingly, the upper spring bearing **31** is rotatably provided in the small-diameter portion **27**B formed in the step shape in the valve stopper **42**B side with respect to the outer peripheral evagination portion **111** (the tool engagement portion **27**A) of the piston nut **27**. The upper spring bearing **31** is prevented from coming off from the outer peripheral evagination portion **111** of the piston nut **27**, and the upper spring bearing **31** interposes the bearing member **120**, and the bearing races **121** and **122** with respect to the valve stopper **42**B. When the upper spring bearing **31** supports the suspension spring **33** with respect to the lower spring bearing **32**, the upper spring bearing **31** becomes rotatable via a small gap with respect to an end surface of the outer peripheral evagination portion **111** (the tool engagement portion **27**A) of the piston nut **27**.

Accordingly, in the front fork **10**, as shown in FIGS. **1** and **4**, the sub suspension spring **130** is interposed between the upper spring bearing **131** in the upper end portion side of the outer tube **11** and the lower spring bearing **132** in the partition wall member **19** side provided in the inner periphery of the inner tube **12**, within the oil reservoir chamber **22** of the inner tube **12**. A part of the other end side of the sub suspension spring **130** is wetted in the oil chamber **22**A of the oil reservoir chamber **22** in which the oil surface L is maintained at the intermediate level within the cup of the partition wall member **19**. The upper spring bearing **131** is constituted by an annular plate inserted and attached to an outer peripheral step portion of the lock nut **24**A for the attaching collar **24** with which the piston rod **23** is engaged. The lower spring bearing **132** is formed by an upper surface facing to the oil reservoir chamber **22** of the rod guide portion **19**A of the partition wall member **19**.

An upper end portion of the main suspension spring **33** mentioned above is supported to the outer tube **11** via the piston rod **23**, the piston **26** and the upper spring bearing **31**, and a lower end portion thereof is supported to the inner tube **12** via the lower spring bearing **32**. An upper end portion of the sub suspension spring **130** is supported to the outer tube **11** via the upper spring bearing **131**, and a lower end portion is supported to the inner tube **12** via the lower spring bearing **132** of the partition wall member **19**. Accordingly, if the outer tube **11** and the inner tube **12** are expanded or contracted at a certain length x, the main suspension spring **33** and the sub suspension spring **130** are expanded or contracted at the same length x, respectively. In other words, the main suspension spring **33** and the sub suspension spring **130** are arranged in parallel to each other, and a total spring constant of the front fork **10** (a combined spring constant of the main suspension spring **33** and the sub suspension spring **130**) K is obtained by a sum of a spring constant Km of the main suspension spring **33** and a spring constant Ks of the sub suspension spring **130**. Accordingly, in the present embodiment, the spring constant Km of the main suspension spring **33** is set to a lower limit in an upper and lower limit range of the spring constant K required for the front fork **10**. The spring constant Ks of the sub suspension spring **130** is set to a difference between a spring constant K (Km+Ks) to be set in the front fork **10** and the spring constant Km of the main suspension spring **33**.

In the front fork **10**, at a time of setting and changing the total spring constant, the main suspension spring **33** is not replaced but is kept assembled between the upper spring beating **31** and the lower spring bearing **32** within the piston side oil chamber **21**B, and only the sub suspension spring **130** is replaced. If the cap **13** is detached from the outer tube **11**, and the piston rod **23** is detached from the attaching collar **24** and the lock nut **24**A existing together with the damping force adjusting apparatus **40**A within the cap **13**, it is possible to easily attach and detach the new and old sub suspension springs **130** to and from the upper end portion of the piston rod **23**.

In accordance with the present embodiment, the following operations and effects can be achieved.

(a) Each of the main suspension spring **33** and the sub suspension spring **130** is interposed between the outer tube **11** side and the inner tube **12** side, and is arranged in parallel to each other. Accordingly, the main suspension spring **33** is set to the spring constant Km corresponding to the lower limit in the upper and lower limit range of the spring constant required for the front fork **10**, and is kept being assembled at a time of replacing the spring. The sub suspension spring **130** is set to the small spring constant Ks corresponding to the difference between the total spring constant (the combined spring constant) (Km+Ks) to be set in the front fork **10** and the spring constant Km of the main suspension spring **33**, and plural kinds of sub suspension springs having the different spring constants Ks can be previously prepared for setting and changing the spring constant of the front fork **10**. Accordingly, the spring constant of the front fork **10** can be set and changed by replacing only the sub suspension spring **130**.

(b) Since it is not necessary to detach the partition wall member in the upper end portion of the inner tube **12** for replacing the sub suspension spring **130**, it is possible to reduce the man hours required to replace the spring in the front fork **10**.

(c) Since the sub suspension spring **130** has the small spring constant, and it is possible to make the coil diameter and the wire diameter narrow and make the surface area small, the reduction of the oil amount of the oil reservoir chamber **22** caused by the replacement of the spring of the front fork **10** can be disregarded.

(d) The main suspension spring **33** within the working fluid chamber **21** is not replaced at a time of replacing the spring of the front fork **10**. Accordingly, the oil flow path flowing through the space between coils of the main suspension spring **33** is not changed in the inner portion of the working fluid chamber **21**, it is possible to suppress the change of the damping force characteristic.

(e) The main suspension spring **33** is designed so as to have an efficient spring constant (critical design), on a stress by selecting a standard coil diameter of the wire material, and the difference from the total spring constant of the front fork **10** can be borne by the sub suspension spring **130**. Accordingly, it is possible to achieve a weight saving without unnecessarily making the wire diameter of the main suspension spring **33** thick (excess design).

(f) Since the sub suspension spring **130** has the small spring constant, and the wire diameter thereof can be made narrow, it is possible to use the wire material having a higher tensile strength even in the same material (for example, JISG3522), and it is possible to reduce a weight per unit strength.

(g) Even in the specification that the allowable stress of the spring, the closed height and the like are hard to be designed by only one spring, it, is possible to easily establish the specification by two springs comprising the main suspension spring **33** and the sub suspension spring **130**.

As heretofore explained, embodiments of the present invention have been described in detail with reference to the drawings. However, the specific configurations of the present invention are not limited to the illustrated embodiments but those having a modification of the design within the range of the presently claimed invention are also included in the present invention.

Although the invention has been illustrated and described with respect to several exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made to the present invention without departing from the spirit, and scope thereof. Therefore, the present invention should not be understood as limited to the specific embodiment set out above, but should be understood to include all possible embodiments which can be encompassed within a scope of equivalents thereof with respect to the features set out in the appended claims.

What is claimed is:

**1**. A hydraulic shock absorber in which an inner tube in an axle side is slidably inserted into an outer tube in a vehicle body side, comprising:

a partition wall member is provided in an inner periphery of the inner tube, a working fluid chamber is comparted in a lower portion of the partition wall member, an oil reservoir chamber is comparted in an upper portion,

a piston support member attached to the outer tube side is inserted into the working fluid chamber through the partition wall member, and a piston sliding within the working fluid chamber is provided in a leading end portion of the piston support member,

wherein a main suspension spring is interposed between an upper spring bearing in the piston support member side attached to the outer tube side and a lower spring bearing in a bottom portion side of the inner tube, within the working fluid chamber of the inner tube,

wherein a sub suspension spring is interposed between an upper spring bearing in an upper end portion side of the outer tube side and a lower spring bearing in the partition wall member provided in an inner periphery of the inner tube, within the oil reservoir chamber of the inner tube, and

wherein a spring constant of the main suspension spring is set to a lower limit in an upper and lower limit range of a spring constant required for the hydraulic shock absorber.

**2**. A hydraulic shock absorber according to claim **1**, wherein a spring constant of the sub suspension spring is set to a difference between a spring constant to be set to the hydraulic shock absorber and a spring constant of the main suspension spring.

**3**. A hydraulic shock absorber according to claim **2**, further comprising a spring load adjusting apparatus supporting a bottom plate of the lower spring bearing in the bottom portion side of the inner tube by an adjust bolt facing to an outer portion at a position deflecting from an axle attaching hole of an axle bracket constructing the bottom portion of the inner tube, and adjusting a spring load of the suspension spring by moving up and down the lower spring bearing on the basis of a peristaltic movement of the adjust bolt.

**4**. A hydraulic shock absorber according to claim **1**, further comprising a spring load adjusting apparatus supporting a bottom plate of the lower spring bearing in the bottom portion side of the inner tube by an adjust bolt facing to an outer portion at a position deflecting from an axle attaching hole of an axle bracket constructing the bottom portion of the inner tube, and adjusting a spring load of the suspension spring by moving up and down the lower spring bearing on the basis of a peristaltic movement of the adjust bolt.

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